

REMARKS

Reconsideration is requested.

Page 1 of the Office Action of October 22, 2010 and the PTO IFW identify the Office Action of October 22, 2010 as a non-final rejection. Pages 13 and 14 of the Office Action identify the Office Action as a final Office Action. The undersigned has left a telephone message for the Examiner on April 22, 2011 requesting confirmation that the Office Action of October 22, 2010 is a non-final Office Action. The Examiner is requested to contact the undersigned, preferably by telephone, in the event anything further is required in this regard.

The undersigned acknowledges, with appreciation, the teleconferences of April 13 and 14, 2011 with the Examiner. The Examiner suggested that the pending patent claims be listed as shown above, with the indicated status identifier. The Examiner confirmed for the undersigned on April 14, 2011 that rejection of the claims based on alleged deficiencies in the Reissue Declaration is obviated by the Reissue Declaration filed June 14, 2005. The rejection stated on page 4 of the Office Action dated October 22, 2010 makes reference to the originally filed Reissue Declaration (i.e., filed June 28, 2004). The Examiner is understood to have now reviewed the later filed Declaration and found it to be acceptable. Confirmation of same in the Examiner's next action, or clarification of any outstanding objection in this regard, is requested.

The applicants understand that once a Reissue Declaration is filed stating an error as a basis of the reissue application, as well as the other required aspects of an original Reissue Declaration as detailed in 37 CFR 1.175(a), the applicants may request

that submission of any required supplemental oath/declaration, such as is being required in §2. of page 4 of the Office Action dated October 22, 2010, be deferred until allowance. See MPEP § 1444. The applicants request deferral of the requirement to submit a supplemental oath/declaration. The applicants note the suggestion of MPEP § 1444 (II) that the “reissue applicant wait until the case is in condition for allowance, and then submit a cumulative supplemental reissue oath/declaration pursuant to 37 CFR 1.175(b)(1).” The Examiner is requested to contact the undersigned by telephone, pursuant to MPEP § 1444, once the case is in condition for allowance, at which time the applicants will prepare and subsequently file the required further Supplemental Reissue Declaration, such as is described in MPEP § 1414.01 and § 1444.

The claims as presented in the Amendment of July 6, 2007 have been represented above in a format described in Rule 137(b)(2) and MPEP § 1453, in response to the objection to the Amendment stated in §3. of page 4 of the Office Action dated October 22, 2010. The amendments shown above have been made relative to the patent, as required by Rule 137(g). Support and basis for the amended claims is described in the Remarks of the Amendment filed July 6, 2007. The Examiner is requested to contact the undersigned, preferably by telephone, in the event anything further is required with regard to the format of the amended and/or originally granted claims.

Claims 1-24 and 34-60 are pending. Claims 25-33 have been canceled, without prejudice.

The Examiner is requested to hold in abeyance the obviousness-type double patenting rejection of claims 1, 3, 14 and 16 over claims 1 and 16 of U.S. Patent 6,097,452 until such time as allowable subject matter is indicated, at which time the applicants will consider further appropriate action.

The following patents are cited in the Office Action of October 22, 2010, in various combinations, as basis the alleged obviousness of the claimed invention:

- D1 - U.S. Patent No. 5,585,951 (Noda),
- D2 - U.S. Patent No. 5,477,360 (Sunohara),
- D3 - U.S. Patent No. 4,877,718 (Moore),
- D4 - U.S. Patent No. 4,460,667 (Landa),
- D5 - U.S. Patent No. 5,331,344 (Miyagawa),
- D6 - U.S. Patent No. 5,128,788 (Takatoh),
- D7 - U.S. Patent No. 5,051,800 (Shoji),
- D8 - U.S. Patent No. 5,359,441 (Mori), and
- D9 - U.S. Patent No. 5,229,644 (Wakai)

These references are referred to herein by the above-noted "document" or "D" numbers D1-D9.

The Section 103 rejection of claims 1-5, 14-17 and 21, over D1, D2 and D3 is traversed. Reconsideration and withdrawal of the rejection are requested in view of the following distinguishing comments.

The rejected claims 1-5, 14-17 and 21 require, among other things, a spectral transmission of the transparent colorless interlayer organic insulating film to have a

lower transmittance for blue light than for green and red light. Claims 1-5, 14-17 and 21 are originally granted claims.

As explained during the prosecution of the parent patent, advantages of an intentionally lower transmittance for blue light as compared to green and red light, include the discovery by the applicants that the interlayer organic film can remain in a resin state to a certain extent such that the cured film may contain a non-reactive functional group that lowers transmittance around the blue light spectrum. See for example, page 30 of the specification or column 9, lines 46-61 of the issued U.S. Patent No. 6,433,851.

Conventionally, many hours of light exposure are needed to react all of the functional groups of a photosensitive organic resin. Long exposure periods were believed necessary to increase the transmittance especially for blue light through the interlayer insulating film. However, the long conventional exposure period reduced the manufacturing productivity of the liquid crystal display device. Applicants realized that shorter exposure periods can be used for interlayer insulating films, provided that lower transmittance for blue light is acceptable. See for example, pages 55-60 and 73-75 of the specification (column 17, line 24 through column 19, line 15 and column 22, line 64 through column 23, line 62 of the issued U.S. Patent No. 6,433,851).

The presently claimed invention has, as an advantage, improving productivity of the liquid crystal display device by shortening the light exposing process of the interlayer insulating film. Because of the short exposure period, the transparent

interlayer organic insulating film has a lower transmission for blue light than that for green and red light.

Even though the photosensitivity thereof may be slightly degraded for blue light, the visual effect of the display is not degraded because the visual sensitivity of the human eye to blue light is lower than for green and red. Applicants have appreciated that an interlayer insulating film with high transmittance for red and green light, and a lesser transmittance for blue light, would still yield a good display having an interlayer insulating film that appears to be transparent to the human eye. The claimed invention requiring this distinction would not have been obvious from the cited combination of art. One of ordinary skill would not have been motivated by the cited art to provide an interlayer insulating film of the claimed invention with reduced transmittance of blue light as compared to red and green light.

The applicants therefore transformed a problem, i.e., poor blue transmittance, into an advantage. The applicants discovered that an interlayer insulating film having a relatively-poor blue transmittance is advantageous with respect to shorter production times. The applicants also discovered that poor blue transmittance is not visually perceptible in the presently claimed invention. These discoveries lead applicants to the display invention that is the subject of the pending claims.

In allowing the claims which issued as claims 1-24 of U.S. Patent No. 6,433,851, Examiner Chowdhury stated as follows as the reasons for allowance:

“None of the prior arts alone or in combination discloses the claimed transmission type liquid crystal display device wherein a transparent colorless interlayer organic insulating film formed from a cured organic polymer and having a

thickness which provides a reduced capacitance between the pixel electrode and the gate line or the source line, the thickness is determined by a light transmittance and a dielectric constant of the film and the transmittance of the transparent interlayer organic insulating film has a lower transmittance for blue light than for green and red light.” See Notice of Allowability dated October 22, 2001 in Application No. 09/757,477.

The applicants discovery, as defined in claims 1-24 of U.S. Patent No. 6,433,851. would not have been obvious over the cited combination of art

The present Examiner asserts that D1 teaches an acrylic resin

“that is photosensitive having a dielectric constant of 3.0-3.5, are properties of an insulating layer which has a lower transmittance for blue light than for green and red light. Thus, wherein a spectral transmittance of the transparent interlayer organic insulating film has a lower transmittance for blue light than that for green and red light is met. (as explained in applicant’s specification [0090] US 2001002857)” See page 7 of the Office Action dated October 22, 2010.

The Examiner relies on column 5, lines 50-55 and column 9, lines 60-67 of D1 for a teaching of “an photosensitive acrylic resin.” See page 6 of the Office Action dated October 22, 2010.

The cited passages of D1 describe the following:

“...pixel electrodes by way of a contact hole through the planarization layer. The above connecting step includes the step of applying photolithography and etching to the planarization layer made from photosensitive resin for perforating the contact hole.

The active-matrix liquid crystal display device of the ...

... because it is exposed in high temperatures in the subsequent processes. To meet the above requirements, the planarization layer 11 is suitably selected from the specified organic materials and inorganic materials. As the organic

materials, for example, an acrylic resin or a polyimide resin may be used. Polyimide resin is excellent in heat resistance; but is slightly colored. On the contrary, acrylic resin is substantially colorless and transparent. These resins are each ...”

The Examiner admits in a separate art rejection (i.e., based on a combination of D1, D4 and D5 as described below) that

“Noda et al [D1] does not disclose a photosensitive resin having a dielectric constant of 3.4 to 3.8, and a spectral transmittance of the transparent interlayer organic insulating film has a lower transmittance for blue light than for green and red light.” See page 8 of the Office Action date October 22, 2010.

The acrylic resin of D1 is a colorless and transparent material. Column 9, lines 53-55 of D1 cited by the Examiner describes that the “planarization layer **11**” of D1 is “generally required to be colorless and transparent”. There is no teaching or suggestion in D1 that a layer corresponding to the insulating layer of the presently claimed invention could or should have a lower transmittance to blue light as compared to green and red light. There is no teaching or suggestion in D1, or the other combined art, that an insulating layer of the claimed invention could be successfully used and that such an insulating layer would provide the advantages discovered by the applicants.

One of ordinary skill will appreciate that blue light has a wavelength of about 475 nm , while green and red light have wavelengths of about 510 nm and 650 nm, respectively. Moreover, one of ordinary skill will appreciate that any give acrylic resin will generally uniformly transmit light in the visible region. The following description from www.rplastics.com demonstrates the generally uniform transmittance of visible light through colorless PLEXIGLAS® (i.e., an acrylic resin):

Home
The Plexiglas® Plastic Library
Acrylics and Flat Fiberglass Panels
Acrylics and Plastic Film, Adhesives & Glues
Plastic Roof
Plastic Tube
Plastic Windows
Plastic Fabrication
Plastic Paint & Ink
Plastic Tanks & Containers
Acrylic Fibers of Plexiglas
Plastics for other Uses
Plastic Furniture & Displays
Acrylics: Hidden-Grain Lenses
Plastic & Glass Mirror
Plastic Mirrors
Plastic Fibers / Products
Plastic Lighting Products
Plastic Orders, Shipping & Returns
Plastic / O. Library Link
Plastic Library - Contact Us
Plastic & Printed Form
About Us
Product Information Form
Privacy Policy
Terms & Conditions
Search

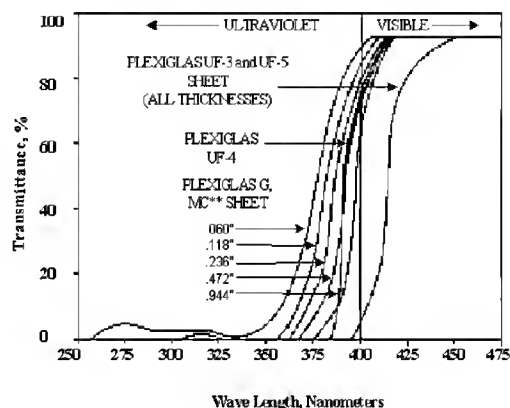
RPlastics — The Midwest Plastics Store

Plastic Sheet Shapes Fabrication > Plexiglas FAQ, Library, Links > Manufacturing & Laboratory
 2010 Plexiglas Sheet > Light Transmittance Values for Plexiglas

Light Transmittance Values for Plexiglass

PLEXIGLAS® SHEET LIGHT TRANSMISSION
 Visible and Ultraviolet Light Transmission in Colorless Sheet

FIGURE 3- Visible and Ultraviolet Transmittance in Colorless Plexiglas Sheet*



*The curves in Figure 3 are typical for these materials; however, values can change slightly with formulation modifications and therefore, should not be used for specification purposes.

ULTRAVIOLET TRANSMITTANCE

Plexiglas® sheet absorbs short wavelength ultraviolet (UV) energy, but transmits most of the long wavelength UV (near wavelengths just short of the visible region). The total UV energy absorbed is about 85%.

The unimpeded UV stability gives Plexiglas® ML and G sheet superior weatherability and makes it the logical choice among plastic materials for outdoor and artificial lighting applications. The absence of visible changes in Plexiglas sheet after prolonged outdoor or artificial light exposure means that no change has taken place in the spectroscopic characteristics of the material in the ultraviolet and visible range. Plexiglas sheet exhibits an increase in UV absorbance caused by sunlight. Most of the drop in UV transmittance of Plexiglas sheet takes place in the first ten years. Absolutely no change occurs in the spectrophotometric curves of these exposed samples between 5 and 10 years outdoors. Plexiglas ML acrylic sheet absorbs 85-90% of all UV rays.

Colorless Plexiglas sheet exhibits the same excellent resistance to discoloration when exposed for 20 years or more to constantly fluorescent lamps, even when the Plexiglas sheet is only two inches from the lamp.

Some applications, such as document preservation, call for a filter material that absorbs more UV energy than ordinary glass but minimal visible light. Plexiglas G UF-3 and Plexiglas MC UF-5 absorb about 90% of all UV rays, as well as a small amount of visible light. Plexiglas G UF-4, developed for mercury vapor lighting applications, can also be used as a protective shield. Plexiglas G UF-4 sheet absorbs slightly more UV energy than Plexiglas G UF-3 and Plexiglas MC UF-5 sheet.

The statements, technical information and recommendations obtained herein are believed to be accurate as of the date hereof. Over the conditions and methods of use of the product and of the information referred to herein are beyond our control. Akzochem expressly disclaims any and all liability, NO WARRANTY OF FITNESS FOR ANY PARTICULAR PURPOSE, WARRANTY OF MERCHANTABILITY, OR ANY OTHER WARRANTY, EXPRESS OR IMPLIED, IS MADE CONCERNING THE GOODS DESCRIBED OR THE INFORMATION PROVIDED HEREIN. The information provided herein relates only to the specific product designated and may not be applicable when such product is used in combination with other materials or in any process. The user should thoroughly test any application before implementation. Nothing contained herein should be construed as an endorsement to selling any patent, and the user is advised to take appropriate steps to be sure that any proposed use of the product will not result in patent infringement.

See MSDS for Health and Safety Considerations.

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plexiglass-transmittance

Plexiglass, Lexan, UHMW, ABS, PTFE, KYDEX, Polyester Film, Plastic Sheet Experts

Plexiglas® sheet is a registered trademark of Akzochem, Inc. Rulon Plexite is an authorized distributor of Plexiglas® acrylic sheet. Plexiglas® is commonly misspelled as Plexiglass, Plexy Glass, & Plexi Glass.

January 2011

Don't see a large Plexiglas® Sheet?
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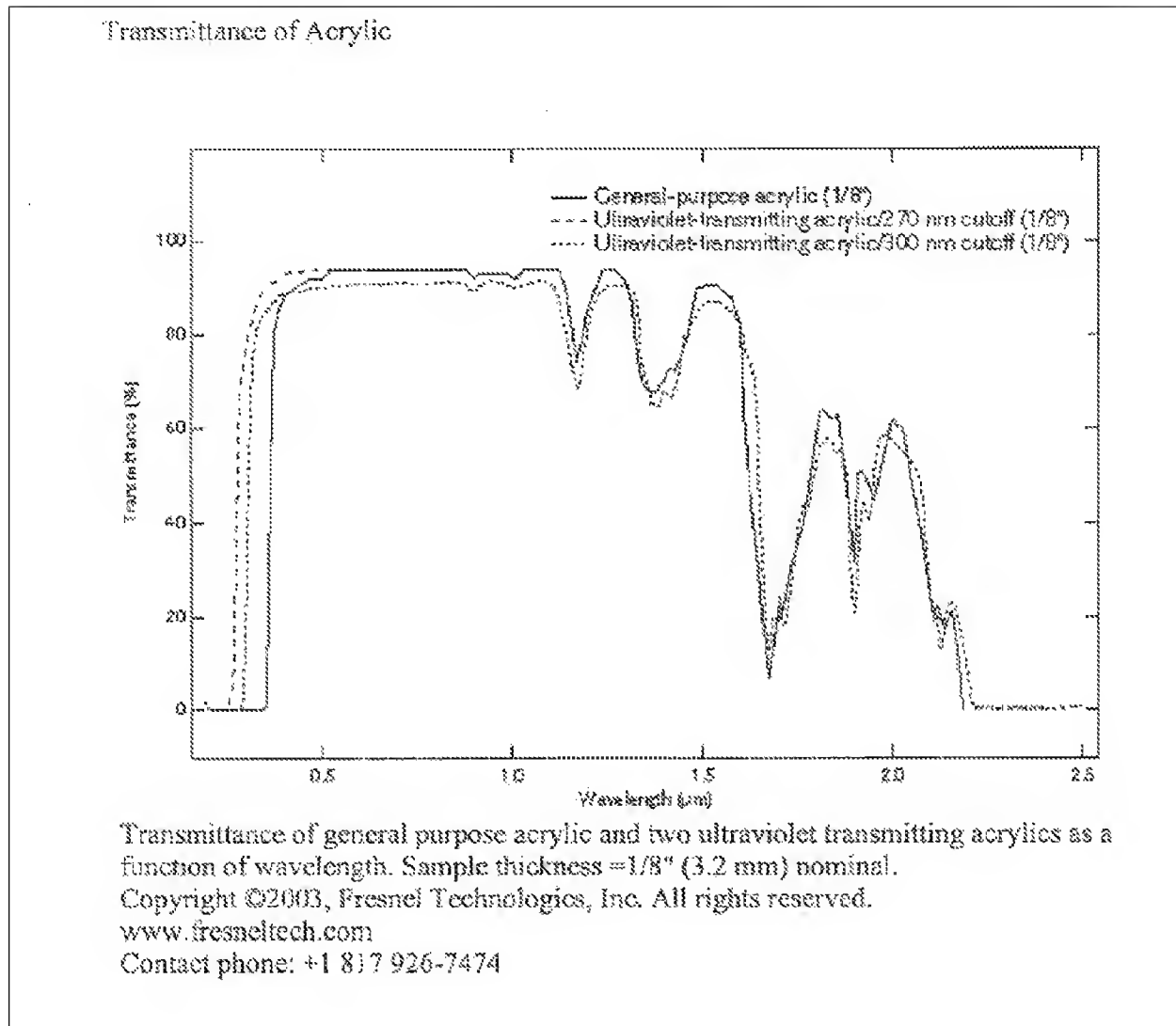
Search

If you don't see it here, ask us about it!

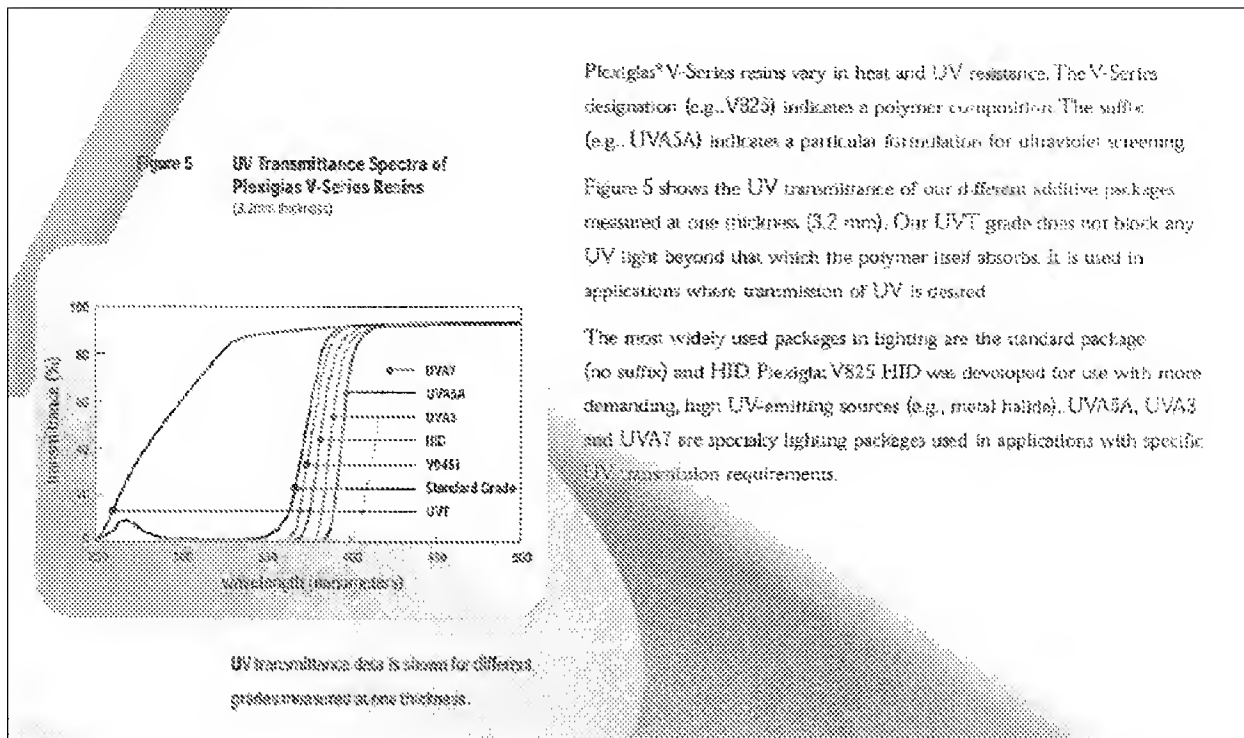
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The following graph from www.resneltech.com further demonstrates similar properties of other acrylic resins:



The following information from Altuglas International (Arkema Group, Arkema Inc., 2000 Market Street, Philadelphia PA (www.altuglasint.com) similarly demonstrates the generally recognized properties of transparent acrylic resins:



The Examiner relies on D2 for an alleged teaching of polyimide having a dielectric constant of a specific value. The Examiner relies on D3 for an alleged teaching that certain polyimides are photosensitive. See page 7 of the Office Action dated October 22, 2010.

The Examiner's reliance on ¶[0090] of the applicants disclosure (i.e., the applicants description of their own disclosed invention in the U.S. Patent Office published version of the specification (US 2001/0002857 A1)) in rejecting the claimed invention is not appropriate. The cited passage of the applicants disclosure provides the following description:

“[0090] The acrylic resin constituting the interlayer insulating film 38 has a dielectric constant of 3.4 to 3.8 which is lower than that of an inorganic film (e.g., the dielectric constant of silicon nitride is 8) and a high transparency. Also, since the spin coating is employed, a thickness as large as 3 .mu.m

can be easily obtained. This reduces the capacitances between the gate line 22 and the pixel electrode 21 and between the source lines 23 and the pixel electrodes 21, lowering the time constant. As a result, the influence of the capacitances between the lines 22 and 23 and the pixel electrode 21 appearing on the display, such as crosstalk, can be reduced, and thus a good and bright display can be obtained. "

The invention of claims 1-5, 14-17 and 21 would not have been obvious in view of the description in the cited art of the use of a colorless and transparent planarization layer of D1.

Withdrawal of the Section 103 rejection of claims 1-5, 14-17 and 21 over the combination of D1, D2 and D3 is requested.

The Section 103 rejection of claims 1-5, 12-17, 21, 23, 24, over D1, D4 and D5 is traversed. Reconsideration and withdrawal of the rejection are requested in view of the above and the following further comments.

As noted above, D1 fails to teach or suggest inclusion of an interlayer insulating film of the claimed invention. Moreover, the benefits of an interlayer insulating film of the claimed invention would not have been obvious or expected from the cited art.

The Examiner relies on D4 for an alleged teaching that an acrylic resin has a dielectric constant of a specific value. The Examiner relies on D5 for an alleged teaching that certain a material containing an acrylate is photosensitive. See pages 8-9 of the Office Action dated October 22, 2010. The cited secondary references (i.e., D4 and D5) fail to cure the deficiencies of the primary reference (D1). The invention of claims 1-5, 12-17, 21, 23, 24, would not have been obvious in view of the cited combination of D1, D4 and D5.

Clarification of the relevance of the Examiner's comments relating to claims 12 and 23 on pages 9-10 of the Office Action dated October 22, 2010, is respectfully requested. The Examiner characterizes the claims 12 and 23 as a "product-by-process" claims and notes that "patentability of a product does not depend on its method of production." The Examiner is urged to appreciate however that claims 12 and 23 further define a property of the transparent interlayer organic insulating film in that it suppresses degradation by resist removing solution used to form the pixel electrode. The claims therefore further define the product of the claim from which they depend (i.e., claims 1 and 14, respectively).

It is noted that the Examiner has asserted that D1 allegedly includes "an photosensitive acrylic resin ... insulating layer is etched" and "the transparent interlayer organic insulating film is cured". See pages 6, 8, 11 of the Office Action dated October 22, 2010.

The Examiner's comments regarding claims 13 and 24 on page 10 of the Office Action dated October 22, 2010 are noted. The Examiner has failed however to demonstrate that the

"transparent insulating layer disclosed in Noda et al [i.e., D1]
is made of the same material ... as the claimed transparent
insulating layer."

Rather, the applicants have demonstrated above and throughout the record that one of ordinary skill in the art would expect an acrylic resin of D1 to provide a relatively constant and uniform transmittance of visible light (i.e., including blue, green and red

light). The Examiner has not adequately supported the Examiner's conclusion that D1 describes a

"transparent insulating layer ... made of the same material ... as the claimed transparent insulating layer."

The cited combination of D1, D4 and D5 would not have made the invention of claims 1-5, 12-17, 21, 23, 24 obvious.

The Section 103 rejection of claims 6-11, 18-20 and 22 over D1, D4, D5 and D6 is traversed. Reconsideration and withdrawal of the rejection are requested in view of the above and the following distinguishing remarks.

Claims 6-11 are dependent from claim 1 and claims 18-20 and 22 are dependent from claim 14. Claims 1 and 14 are patentable over the combination of D1, D4 and D5, for at least the reasons described above. The Examiner appreciates that dependent claims 6-11, 18-20 and 22 are patentable over the combination of D1, D4 and D5, as same are not included in the above rejection based on same. The additional teachings of D6 fails to cure at least the deficiencies of the combination of D1, D4 and D5 noted above.

The Examiner relies on D6 for an alleged teaching of the use of a

"positive type photosensitive resin including a copolymer glycidyl added for a thermally reactive function which has a reactive peak at a wavelength of 365 nm." See page 11 of the Office Action dated October 22, 2010.

The additional disclosure of D6 fails to cure the deficiencies of the combination of D1, D4 and D5 and withdrawal of the Section 103 rejection of claims 6-11, 18-20 and 22 over D1, D4, D5 and D6 is requested.

The Section 103 rejection of claims 34, 35, 43, 44, 52 and 53 over D1, D2 and D3 is traversed.

The rejected claims define a liquid crystal display device (claims 34, 35, 43 and 44) requiring, among other things, a photosensitive resin having a dielectric constant of about 3.4-3.5; and a method of forming a liquid crystal display device requiring, among other things, providing a photo-imageable insulating layer having a dielectric constant in a range of from about 3.4 to about 3.8.

D1 fails to describe a photosensitive resin having a dielectric constant of the claimed invention. As noted above, the Examiner relies on D1 for an alleged teaching of an acrylic resin or a polyimide resin “planarization layer” or “planarization film **1784**”. See page 6 of the Office Action dated October 22, 2010.

The Examiner is understood to rely on D2 to allegedly demonstrate that a polyimide having a dielectric constant of 3.5 exists and the Examiner is understood to rely on D3 to demonstrate that a polyimide can be photosensitive.

The Examiner concludes from the combination of D1, D2 and D3 that the dielectric constant of the acrylic resin of D1 is in the range of 3.0-3.5. See page 7 of the Office Action dated October 22, 2010. Clarification is requested however, in the event that rejection is maintained, as to how the polyimide descriptions of D2 and D3 could be used by the Examiner to demonstrate an alleged inherent property of an acrylic resin. The Examiner will appreciate that polyimides and acrylic resins are chemically distinct polymers, with distinct properties. In the event the rejections based on an alleged

inherent teaching of D1, based on D2 and D3, the Examiner is requested to clarify if the polyimide resin of D1 is being alleged to have a dielectric constant of 3.0-3.5.

The disclosure of a polyimide with a dielectric constant of 3.5 in D2 does not necessarily demonstrate that the acrylic resin of D1 has a dielectric constant in the range of 3.0-3.5, as appears to be a basis of the Section 103 rejection. Moreover, the disclosure of a polyimide with a dielectric constant of 3.5 in D2 does not necessarily demonstrate that the polyimide of D1 has a dielectric constant in the range of 3.0-3.5.

The Federal Circuit has explained in *In re Rijckaert*, 28 USPQ2d 1955, 1957 (Fed. Cir. 1993), for example, the following with regard to inherency and obviousness:

The mere fact that a certain thing may result from a given set of circumstances is not sufficient [to establish inherency.]” In *re Oelrich*, 666 F.2d 578, 581-82, 212 USPQ 323, 326 (CCPA 1981) (citations omitted) (emphasis added). “That which may be inherent is not necessarily known. Obviousness cannot be predicated on what is unknown.” In *re Spormann*, 363 F.2d 444, 448, 150 USPQ 449, 452 (CCPA 1966). Such a retrospective view of inherency is not a substitute for some teaching or suggestion supporting an obviousness rejection. See *In re Newell*, 891 F.2d 899, 901, 13 USPQ2d 1248, 1250 (Fed.Cir. 1989).

The fact that resins of D1 may have a dielectric constant in the range of a component of the claimed invention is not sufficient to establish inherency. Moreover, the fact that the resins of D1 may have a dielectric constant in the range of the claimed invention indicates that the dielectric constants of the resins of D1 are not necessarily known and, as noted above, obviousness cannot be predicated on what is unknown.

The dielectric constant of a resin of D1 does not necessarily flow from the disclosure of D1. The Examiner is requested to appreciate in this regard that the fact

that D1 may teach an acrylic resin or a polyimide resin, combined with the existence of resins having a dielectric constant in the required range, is not sufficient to establish a prima facie case of obviousness as the Examiner has failed to establish that all acrylic resins or polyimide resins of D1 necessarily meet the requirements of the claims or that it would have been obvious to have specifically selected the claimed resins, of all the virtually infinitely possible resins, with the other aspects required by the claimed invention, to have made the claimed invention.

Withdrawal of the Section 103 rejection of claims 34, 35, 43, 44, 52 and 53 over D1, D2 and D3 is requested.

While not believed to be required as the Examiner has failed to establish a prima facie case of obviousness, the applicants have previously submitted evidence that acrylic resins may have a wide range of dielectric constants.

Specifically, the applicants have cited US Patent 5,076,963 to Kameyama et al which describes certain acrylic resins as having a dielectric constant of values of 10 or greater . Col. 4, lines 18 of US Patent 5,076,963 to Kameyama is noted which lists numerous acrylic compounds and which further states that such compounds have "a high dielectric constant of not less than 10". See, also, col. 7, lines 3 - 5, col. 8, Example 1, and col. 10, example 8. Kameyama Example 1 describes an insulator layer of acrylate with a dielectric constant of 30.

Claims 34, 35, 43, 44, 52 and 53 are patentable over the combined teachings of D1, D2 and D3 and withdrawal of the Section 103 rejection based on same is requested.

The Section 103 rejection of claims 34, 35, 37-39, 43, 44, 46-48, 52, 53 and 55-57 over D1, D4, and D5 is traversed. Reconsideration and withdrawal of the rejection are requested in view of the above and the following distinguishing comments.

The deficiencies of D1 noted above with regard to claims 34, 35, 43, 44, 52 and 53 are not cured by secondary references D4 and D5. Claims 37-39 are dependent from claim 34, claims 46-48 are dependent from claim 43 and claims 55-57 are dependent from claim 52.

The rejected claims define a liquid crystal display device (claims 34, 35, 37-39, 43, 44 and 46-48) requiring, among other things, a photosensitive resin having a dielectric constant of about 3.4-3.5; and a method of forming a liquid crystal display device requiring, among other things, providing a photo-imageable insulating layer having a dielectric constant in a range of from about 3.4 to about 3.8.

As noted above, D1 fails to describe a photosensitive resin having a dielectric constant of the claimed invention. As noted above, the Examiner relies on D1 for an alleged teaching of an acrylic resin or a polyimide resin “planarization layer” or “planarization film **1784**”. See page 6 of the Office Action dated October 22, 2010.

D4 is cited by the Examiner to

“show the scientific fact that the acrylic resin (metha methacrylate) used to make the insulator in Noda et al [D1] has a dielectric constant property of 3.0-3.5 which are overlapping ranges of the claims ranges 3.4-3.5.” See pages 8-9 of the Office Action date October 22, 2010.

For the reasons noted above with regard to the rejection based on the combination of D1, D2 and D3, the applicants submit, with due respect, that the existence of an acrylic resin with a specific dielectric constant, such as may be described by D4, would not have made it obvious to have made the claimed invention and the existence of the resin does not demonstrate that the a resin of D1 is necessarily a resin having the characteristics of the secondary reference.

D4 may describe a dielectric constant range for an acrylic resin however the applicants have demonstrated that acrylic resins also exist that have dielectric constants outside the range described by D4. There is nothing the combination of cited art that would have led one of ordinary skill in the art to have made the claimed invention or to have believed that an acrylic resin of D1 is any more an acrylic resin of D4 as compared to any other acrylic resin.

Beyond the disclosure of US Patent 5,076,963, discussed above, the applicants submit the following excerpt from www.asiinstr.com, indicating that the dielectric constant of acrylic resins can range from 2.7-4.5:

HOW TO USE THIS GUIDE:

The following Dielectric Constants are given at specific temperatures. If your product's temperature is significantly different from those listed there is a good chance that the Dielectric Constant may be different from the values listed.

The products in this reference are listed in alphabetical order and are grouped in sections by the first letter of their name. Proper chemical names were used. If you know the correct spelling of the name of the product you wish to review then use the "Find" feature on the web browser to locate the name in the list. You may also click on the letter from the alphabetical table to go directly to the beginning of that alphabetic section.

Dielectric Constants Chart

Section A	
A B C D E F G H I J K L M N O P Q R S T U V W X Y Z NUMERIC	
ABS RESIN, LUMP 2.4-4.1 ABS RESIN, PELLET 1.9-2.6 ACENAPHTHENE (70° F) 3.9 ACETAL (70° F) 3.8 ACETAL BROMIDE 18.5 ACETAL DOXIME (68° F) 3.4 ACETALDEHYDE (41° F) 21.8 ACETAMIDE (68° F) 4.1 ACETAMIDE (180° F) 59.0 ACETANILIDE (71° F) 2.9 ACETIC ACID (68° F) 6.2 ACETIC ACID (38° F) 4.1 ACETIC ANHYDRIDE (68° F) 21.0 ACETONE (77° F) 20.7 ACETONE (127° F) 17.7 ACETONE (32° F) 1.0159 ACETONITRILE (70° F) 37.6 ACETOPHENONE (78° F) 17.3 ACETOXIME (24° F) 3 ACETYL ACETONE (68° F) 23.1 ACETYL BROMIDE (68° F) 16.6 ACETYL CHLORIDE (68° F) 15.8 ACETYLE ACETONE (68° F) 25.0 ACETYLENE (32° F) 1.0217 ACETYLMETHYL HEXYL KETONE (66° F) 27.9 ACRYLIC RESIN 2.7-4.5 ACETAL 21.0-3.6 AIR 1 AIR (DRY) (68° F) 1.000538 ALCOHOL, INDUSTRIAL 18-31 ALKYD RESIN 3.5-5 ALLYL ALCOHOL (56° F) 22.0 ALLYL BROMIDE (66° F) 17.8 ALLYL CHLORIDE (68° F) 6.2 ALLYL IODIDE (66° F) 6.1 ALLYL ISOTHIOCYANATE (64° F) 17.2 ALLYL RESIN (CAST) 3.6-4.5 ALUMINA 9.3-11.5 ALUMINA 4.5 ALUMINA CHINA 3.1-3.9 ALUMINUM BROMIDE (212° F) 3.4 ALUMINUM FLUORIDE 2.2 ALUMINUM HYDROXIDE 2.2 ALUMINUM OLEATE (68° F) 12.4 ALUMINUM PHOSPHATE 6.0 ALUMINUM POWDER 1.8-1.8 AMBER 2.8-2.9 AMINOALKYD RESIN 3.8-4.2 AMMONIA (-74° F) 25 AMMONIA (-30° F) 22.0 AMMONIA (40° F) 18.9	AMMONIA (69° F) 18.5 AMMONIA (GAS?) (32° F) .5072 AMMONIUM BROMIDE 7.2 AMMONIUM CHLORIDE 7.0 AMYL ACETATE (68° F) 5.0 AMYL ALCOHOL (-180° F) 35.5 AMYL ALCOHOL (68° F) 15.8 AMYL ALCOHOL (140° F) 11.2 AMYL BENZOATE (68° F) 5.1 AMYL BROMIDE (50° F) 6.3 AMYL CHLORIDE (52° F) 6.0 AMYL ETHER (60° F) 3.1 AMYL FORMATE (66° F) 5.7 AMYL IODIDE (62° F) 6.9 AMYL NITRATE (62° F) 9.1 AMYL THIOCYANATE (68° F) 17.4 AMYLAMINE (72° F) 4.6 AMYLENE (70° F) 2.0 AMYLENE BROMIDE (58° F) 5.8 AMYLENETETRABROMOXYLATE (66° F) 4.4 AMYLMERCAPTAN (88° F) 4.7 ANILINE (32° F) 7.8 ANILINE (66° F) 7.3 ANILINE (122° F) 6.5 ANILINE FORMALDEHYDE RESIN 3.5-3.6 ANILINE RESIN 3.4-3.8 ANISALDEHYDE (68° F) 15.8 ANISALDOXINE (145° F) 9.2 ANISOLE (68° F) 4.3 ANTIMONY TRICHLORIDE 5.3 ANTIMONY PENTACHLORIDE (88° F) 3.2 ANTIMONY TRIBROMIDE (212° F) 26.9 ANTIMONY TRICHLORIDE (166° F) 33.9 ANTIMONY TRICHLORIDE 5.3 ANTIMONY TRICODIDE (347° F) 13.9 APATITE 7.4 ARGON (-376° F) 1.5 ARGON (68° F) 1.000513 ARSENIC TRIBROMIDE (98° F) 19.0 ARSENIC TRICHLORIDE (150° F) 7.0 ARSENIC TRICHLORIDE (70° F) 12.4 ARSENIC TRIIODIDE (302° F) 7.6 ARSINE (-148° F) 2.5 ASBESTOS 3.0-4.8 ASH (FLY) 1.7-2.0 ASPHALT (75° F) 2.6 ASPHALT, LIQUID 2.5-3.2 AZOXYANISOLE (122° F) 2.6 AZOXYBENZENE (104° F) 5.1 AZOXYPHENITOLE (302° F) 6.8
Section B	
A B C D E F G H I J K L M N O P Q R S T U V W X Y Z NUMERIC	
BAKELITE 3.5-5.0 BALLAST 5.4-5.6	BROMACEYAL BROMIDE 12.6 BROMAL (70° F) 7.6

Also attached is a copy of Park et al ("Studies on poly(methyl methacrylate) dielectric layer for field effect transistor: Influence of polymer tacticity", Thin Solid Films 515 (2007) 4041-4044) wherein the dielectric constant of PMMA resins was at least dependent on tacticity and heat treatment (ranging from 2.5-3.0).

One of ordinary skill would not reasonably expect from the cited art that the acrylic resin of D1 has a dielectric constant range of a resin of D4. One of ordinary skill would not have been motivated by the cited combination of art to have made the claimed invention, requiring the recited photo-imageable insulating layer.

The applicants note that the Examiner has asserted that the "planarization layer" of D1 corresponds to an insulating layer of the claimed invention. The applicants submit however that the planarization layers (**11** and **1784**) of D1 are not described in D1 as an insulator. Rather, the applicants believe that the insulation effect in D1 is accomplished by two other layers. Specifically, in Figure 1 of D1 the insulation layers are layers **5** and **8**¹. In Figure 17 of D1 describes insulation layers **1778** and **1781**. One of ordinary skill will appreciate that both the planarization films **11** and **1784**, in Figures 1 and 17, respectively, are formed on top of two insulating layers, namely the first insulating film **5**, **1778** (respectively in D1 Figure 1 and D1 Figure 17) and the second insulating film **8**, **1781** (respectively in D1 Figure 1 and D1 Figure 17). D1 teaches therefore insulating films that are separate from the planarization film **11**, **1784** relied upon by the present Examiner as allegedly corresponding to the insulating layer of the claimed invention.

¹ The two insulating films 5 and 8 are formed from, for example a glass doped with phosphorous, and are totally different from the claimed interlayer insulating film.

Withdrawal of the Section 103 rejection of claims 34, 35, 37-39, 43, 44, 46-48, 52, 53 and 55-57 over D1, D4, and D5 is requested.

The Section 103 rejection of claims 40, 41, 49, 50, 58 and 59 over D1, D4, D5 and D7 is traversed. Reconsideration and withdrawal of the rejection are requested in view of the above and the following further comments.

Claims 40 and 41 are dependent from claim 34, claims 49 and 50 are dependent from claim 43 and claims 58 and 59 are dependent from claim 52. The Examiner relies on D7 for an alleged teaching of

“a contact layer made of amorphous silicon (17a, 17b) over the semiconducting layer (15).” See page 12 of the Office Action dated October 22, 2010.

D7 fails to cure the above noted deficiencies of the combination of D1, D4 and D5. The rejected claims, which all define over the combination of D1, D4 and D5 for reasons that are not cured by D7, would not have been obvious in view of the cited combination of D1, D4, D5 and D7. Withdrawal of the Section 103 rejection of claims 40, 41, 49, 50, 58 and 59 over D1, D4, D5 and D7 is requested.

The Section 103 rejection of claims 36, 45, 54 and 60 over D1, D4, D5 and D8 is traversed. Reconsideration and withdrawal of the rejection are requested in view of the above and the following further comments.

The Examiner relies on D8 as a disclosure of a

“pixel aperture is at least 80% to improve the efficiency of the utilized light.” See page 13 of the Office Action dated October 22, 2010.

Claim 36 is dependent from claim 34, claim 45 is dependent from claim 43 and claims 54 and 60 are dependent from claim 52.

D8 fails to cure the above noted deficiencies of the combination of D1, D4 and D5. The rejected claims, which all define over the combination of D1, D4 and D5 for reasons that are not cured by D8, would not have been obvious in view of the cited combination of D1, D4, D5 and D8. Withdrawal of the Section 103 rejection of claims 36, 45, 54 and 60 over D1, D4, D5 and D8 is requested.

The Section 103 rejection of claims 42 and 51 over D1, D4, D5 and D9 is traversed. Reconsideration and withdrawal of the rejection are requested in view of the above and the following further comments.

Claim 42 is dependent from claim 34 and claim 51 is dependent from claim 43.

D9 fails to cure the above noted deficiencies of the combination of D1, D4 and D5. The rejected claims, which all define over the combination of D1, D4 and D5 for reasons that are not cured by D9, would not have been obvious in view of the cited combination of D1, D4, D5 and D9. Withdrawal of the Section 103 rejection of claims 42 and 51 over D1, D4, D5 and D9 is requested.

The claims are submitted to be in condition for allowance and a Notice to that effect is requested. The Examiner is requested to contact the undersigned, preferably by telephone, in the event anything further is required.

SHIMADA et al
Appl. No. 10/771,263
Atty. Ref.: 829-620
Amendment
April 22, 2011

Respectfully submitted,

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Studies on poly(methyl methacrylate) dielectric layer for field effect transistor: Influence of polymer tacticity

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Abstract

Electrical properties of three kinds of poly(methyl methacrylate) (PMMA) with different tacticity, i.e. isotactic(*i*), syndiotactic(*s*), and atactic(*a*), were investigated for the application in field effect transistor. Metal-insulator-silicon structures were fabricated via spin coating PMMA on heavily doped p-type silicon (p⁺-Si) followed by evaporating gold electrode. The electrical characteristics were remarkably improved by heat-treatment at temperatures 40 K above glass transition temperatures of PMMAs. Among the three PMMA isomers, *i*-PMMA was observed to possess the highest dielectric strength (1.1 MV/cm) with the lowest leakage current density, but also the lowest dielectric constant ($k=2.5$). Top-contact thin film transistors fabricated with the configuration of NiO_x/pentacene/*i*-PMMA/p⁺-Si, where the NiO_x being used as a source/drain electrode, displayed relatively a decent field effect mobility of 0.042 cm²/V-s which is not that low with such a low dielectric capacitor as thick *i*-PMMA film.
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Keywords: Gate insulator; Tacticity; Field effect transistor; Poly(methyl methacrylate); Organic field effect transistor; Electrical properties and measurements

1. Introduction

Organic thin film transistors (OTFT) have attracted attentions due to their apparent advantages over inorganic thin film transistors in terms of mechanical flexibility, light weight, and low processing cost [1]. OTFT manufactured using pentacene as channel layer has been acknowledged as one of the most promising examples and the performance has been remarkably improved for the last decade [2,3]. Although the characteristic properties of pentacene TFTs such as field effect mobility, on/off current ratio, and threshold voltage were reported to be comparable to those of amorphous Si TFTs, there has not been enough progress on organic dielectric materials suitable for reliable OTFT [4,5]. Polymeric materials used for gate dielectric have been limited to poly(methyl methacrylate) (PMMA), poly-4-

vinylphenol, and polyimides in most of studies [4–8], and there still remains large room for improving their properties.

PMMA is categorized into three species with respect to its tacticity, i.e. isotactic(*i*-), syndiotactic(*s*-), and atactic(*a*-), depending on the way that pendant methacrylate groups are arranged along the backbone chain of a polymer (Fig. 1), which led to different tertiary structures. Among three PMMAs only *a*-PMMA has been used as dielectric materials, and electrical characteristics of thin films made of other isomers have not been reported. We here begin with measuring dielectric strength and capacitance (dielectric constant) of thin films made of various PMMAs as cast and annealed above glass transition temperatures (T_g). Heat-treatment would facilitate the rearrangement of the polymer chains, which reduces the vacant volume present within the amorphous chains and helps chains to be packed close to each other [9]. It was observed that electrical properties of *i*-PMMA were superior to other PMMA isomers and these could be greatly improved by the heat-treatment. Secondly, top-contact thin film transistors with the configuration of NiO_x/pentacene/*i*-PMMA/p⁺-Si, where NiO_x was used as a source and drain electrodes and heavily doped

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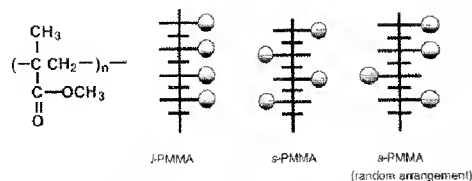


Fig. 1. Repeating unit of PMMA polymer and the schematic views of PMMAs with different tacticity: isotactic, syndiotactic and atactic PMMA, respectively. Shaded circles represent methacrylate groups.

p-type silicon ($\text{p}^+\text{-Si}$) was used as gate electrode, were fabricated. NiO_x was chosen since it has recently been shown to be a promising electrode material for pentacene-based transparent TFTs due to its good sheet resistance ($\sim 60 \Omega/\square$) and work function that was well matched to that of pentacene [10].

2. Experimental details

i-PMMA and *s*-PMMA were purchased from Polyscience, and *a*-PMMA were from Pressure Chemical, and were used without further purification. The characteristics of these molecules are listed in Table 1. Each PMMA was dissolved into anisole solvent and then stirred over 6 h. The PMMA gate dielectric layers were deposited on $\text{p}^+\text{-Si}$ substrate ($0.01\text{--}0.02 \Omega \text{ cm}$) by spin coating from solutions at appropriate concentrations. (6.3 wt.%, 13 wt.%, and 10.5 wt.% for *i*-PMMA, *s*-PMMA, and *a*-PMMA, respectively) The solutions were spun at 3000 rpm for 40 s to form uniform films. Prior to spin coating, the substrates were ultrasonically cleaned in chloroform, methanol, and de-ionized water in that order. The wafers were then dipped into buffered oxide etchant ($\text{HF:H}_2\text{O}=1:6$) to remove native oxide. Thicknesses of the films were determined to be $\sim 640 \text{ nm}$ by surface profilometry. To study the effect of heat-treatment, half of PMMA thin films were heat-treated at temperatures 40 K above T_g (100 °C, 170 °C and 160 °C for *i*-PMMA, *s*-PMMA, and *a*-PMMA, respectively) for 1 h in vacuum oven and the others were dried in vacuum desiccator. A 1 h annealing time was chosen to allow enough time for the polymer to relax to the equilibrium and to avoid possible degradation of the films during excessively long annealing. It was verified that larger annealing time did not change the thickness of the film any further. Gold electrode was then evaporated on the PMMA films at a base pressure of about $7 \times 10^{-4} \text{ Pa}$ for the measure-

Table 1
Molecular characteristics of PMMAs

	% Tacticity	Number average molecular weights (Mn)	Polydispersity indices (Mw/Mn)	Glass transition temperature (°C)
<i>i</i> -PMMA	98	118,000	1.32	60
<i>s</i> -PMMA	>79	133,000	1.16	130
<i>a</i> -PMMA	n.a.	160,000	1.06	120

% Tacticity of *a*-PMMA is not available.

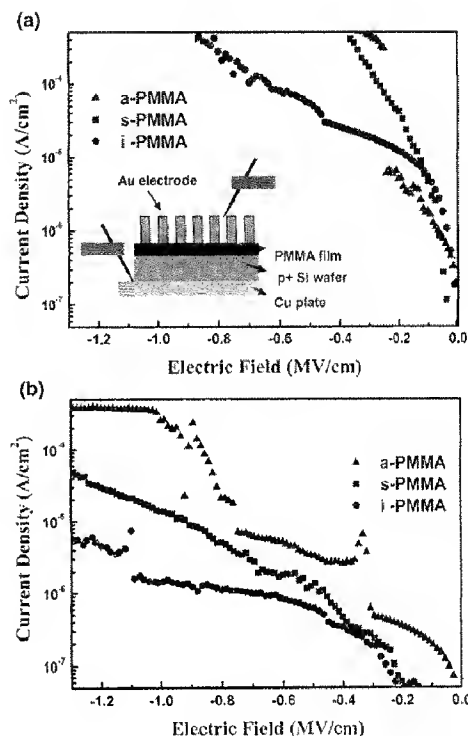


Fig. 2. Current density–electric field characteristics of PMMA with different tacticity: (a) without heat-treatment, and (b) after heat-treatment at $T_g + 40 \text{ K}$ for 1 h. Schematic view inside shows our MIS structure for J–E measurements.

ment of dielectric strength and capacitance. Inset of Fig. 2(a) shows the schematic of our metal–insulator–semiconductor (MIS) structure prepared for the measurements of current density–electric field (J–E) and capacitance–frequency (C–f) characteristics.

For TFT device fabrication (inset in Fig. 4), channels and source/drain electrodes were sequentially patterned on PMMA film through shadow masks at room temperature by thermal evaporation in vacuum chamber where base pressure was $1.3 \times 10^{-4} \text{ Pa}$. The thermal deposition rate was fixed to 1 Å/s for the evaporation of pentacene (Aldrich Chem. Co., $\sim 99\%$ purity) and to 30 Å/s for the evaporation of NiO powder (99.97% purity) [10]. The thicknesses of pentacene and NiO_x films were 50 and 100 nm, respectively, as monitored by a quartz crystal oscillator and confirmed by ellipsometry. The nominal channel length and width were 90 and 500 μm , respectively.

All current–voltage (I–V) relations for MIS and OTFT structures were performed using semiconductor parameter analyzer (Agilent 4155C). I–V characteristics for MIS structures were converted into J–E relation after taking the thickness of dielectric layer into account. The C–f measurements were also made with impedance analyzer (HP 4192A) in the dark. All the

Table 2

Dielectric properties and thicknesses of PMMA films with different tacticity

	Film thickness (nm)	Dielectric strength (MV/cm)	Capacitance (nF/cm ²)	Dielectric constant
<i>i</i> -PMMA	570 (640)	1.1	3.9 (4.0)	2.5 (2.9)
<i>s</i> -PMMA	600 (640)	0.6	4.3 (4.1)	2.9 (3.0)
<i>a</i> -PMMA	600 (640)	0.3	4.1 (4.1)	2.8 (3.0)

The values in parenthesis are the ones obtained without heat-treatment. Dielectric strength defined as the electric field where current density begins to exceed 2×10^{-6} A/cm².

measurements were carried out in air ambient and room temperature conditions.

3. Results and discussions

Fig. 2 exhibits the J–E characteristics of PMMAs with different tacticity, before and after heat-treatment. After spin coating, the polymer molecules exist in nonequilibrium conformation extended toward the surface and radial direction of spinning, and surplus free volume should also be left over due to abrupt evaporation of solvent. While polymer molecules are not mobile enough for conformational transitions below T_g , heat-treatment above T_g facilitates relaxation toward equilibrium conformation to fill up that free volume [9]. Thickness reduction of about 6% for *s*-PMMA and *a*-PMMA films, and 11% for *i*-PMMA were observed (Table 2). Larger volume reduction in case of *i*-PMMA is attributed to the better packing of polymer chains associated with crystallization [11]. Because the electric field in voids is higher than the average field in the dielectric film, the dielectric strength of the PMMA films with some residual voids is expected to be less than that of the continuous solid films without voids. As shown in Fig. 2(a) and (b), PMMAs without heat-treatment, show leakage current that is too high to be used for dielectric in TFT while with the treatment significantly improved J–E characteristics were achieved. Dielectric strength defined as the electric field where current density begins to exceed 2×10^{-6} A/cm² were listed in Table 2. Among the three

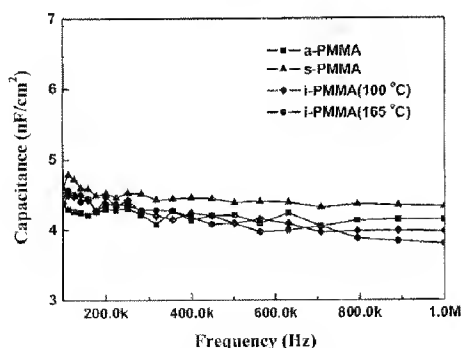


Fig. 3. Capacitance–frequency characteristics of PMMA with different tacticity after heat-treatment at $T = T_g + 40$ K for 1 h. The data for *i*-PMMA annealed at 165 °C for 1 h are also shown.

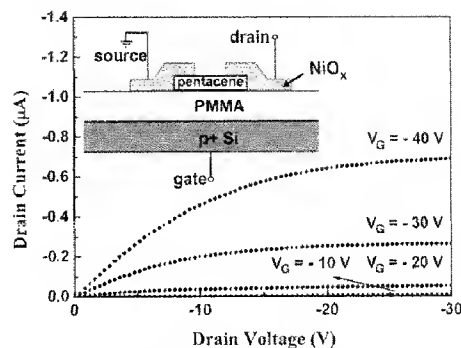


Fig. 4. Drain current–drain voltage characteristics of NiOx(100 nm)/pentacene (50 nm)/*i*-PMMA(570 nm, heat-treated)/heavily doped p⁺-Si transistor devices.

PMMAs, *i*-PMMA appeared to have the most superior J–E characteristics.

Fig. 3 displays the C–f characteristics of PMMA films after heat-treatment. The capacitance data hardly varied with frequency, while relatively unstable capacitance patterns were observed for the films without heat-treatment, which reflect that the presence of more free volume facilitates various dielectric relaxations [12]. Given the capacitance (measured at 1 MHz), film thickness, and electrode area, we calculated dielectric constant as also summarized in Table 2. According to the table, dielectric constant becomes smaller after heat-treatment, and particularly significant reduction (from 2.9 to 2.5) was observed in the dielectric constant of *i*-PMMA. It is likely that the compact packing of molecules, due to the heat-treatment, may hinder the chain rotation of ester groups that are responsible for dipole moment to be aligned under the applied bias. We also annealed *i*-PMMA at 165 °C which is above melting point of *i*-PMMA. In this case, the thickness of *i*-PMMA film was maintained to be almost identical to that of *i*-PMMA film that was annealed at $T = T_g + 40$ K. We have also measured the contact angle of the droplets of de-ionized water on all PMMA

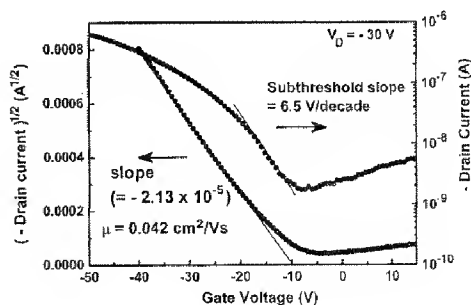


Fig. 5. $\sqrt{-I_D}$ – V_G and $\text{Log}_{10}(-I_D)$ – V_G characteristics of NiOx(100 nm)/pentacene (50 nm)/*i*-PMMA(570 nm, heat-treated)/heavily doped p⁺-Si transistor devices under saturation regime ($V_D = -30$ V).

films. Regardless of tacticity and heat-treatment, an identical contact angle close to 65° was observed, which means that the surface energy difference among all the PMMAs is not conceivable.

Figs. 4 and 5 demonstrate the drain current–drain voltage (I_D – V_D) and the drain current–the gate voltage (I_D – V_G) curves, respectively, for our TFT device that consists of NiO_x (100 nm)/pentacene(50 nm)/*i*-PMMA(570 nm, heat-treated)/ p^+ -Si. We selected only *i*-PMMA as the TFT dielectric layer because of its low leakage current (as demonstrated in Fig. 2(b)). The results obtained using conventional *a*-PMMA can be found elsewhere [13,14]. Well-saturated output characteristics with increasing drain voltage were observed in Fig. 4. According to $\sqrt{I_D}$ – V_G curve of Fig. 5, threshold voltage was observed at -10 V which is significantly smaller than the values reported elsewhere (-15 V [13] and -27.5 V [14].) for pentacene TFTs using *a*-PMMA and Au as gate dielectric and source/drain electrode, respectively. This means that carrier trapping at the interfaces between pentacene and heat-treated *i*-PMMA layer in our device is more or less restricted [14]. Field effect mobility could be extracted from square root of absolute values of drain current versus gate voltage curve. Our TFT exhibited mobility of $0.042 \text{ cm}^2/\text{V}\cdot\text{s}$ which is larger than or comparable to the values reported elsewhere [13,14]. As charge carrier transport occurs within a few monolayer of pentacene layer, the difference in microstructure at the interface between *i*-PMMA dielectric and pentacene might have influenced the hole transport [13]. The current modulation ($I_{\text{on}}/I_{\text{off}}$) was less than 10^3 under a drain saturation condition of $V_D = -30$ V, which is due to the large leakage current. Further improvement would be needed for *i*-PMMA to be utilized for high performance organic transistor. The experimental results reported hitherto show that *i*-PMMA possesses the interesting dielectric properties and is judged to be useful candidate as gate insulator material for organic TFT.

4. Conclusions

We have investigated the electrical properties of three kinds of PMMA with different tacticity for the application in field effect transistor. As heat-treatment of PMMAs at $T_g + 40$ K greatly improved dielectric characteristics, among the three

PMMAs isomers, *i*-PMMA displayed the highest dielectric strength (1.1 MV/cm) with the lowest leakage current density but also the lowest dielectric constant ($k=2.5$). We fabricated pentacene-based TFT that consists of thermally evaporated NiO_x , spin-coated and then heat-treated *i*-PMMA, and p^+ -Si for the source-drain electrodes, gate dielectric, and gate electrode, respectively. Our TFT exhibited a field effect mobility as large as $0.042 \text{ cm}^2/\text{V}\cdot\text{s}$ which is not that low with such a low dielectric capacitor as 570 nm-thick *i*-PMMA film. Low threshold voltage of -10 V were also observed. We conclude that *i*-PMMA among three isomers showed the best dielectric properties and may be a promising gate insulator for pentacene TFT.

Acknowledgement

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